MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210)

PPH0046 – MECHANICS

(Foundation in Engineering)

15 FEBRUARY 2023
2.30 p.m. - 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 3 pages excluding the cover page and the appendices with **TEN** questions only.
2. Answer **ALL** questions. Distribution of the marks for each question is given .
3. Write all your answers in the Answer Booklet provided.
4. All necessary workings must be shown.

Section A [LO1, 20 marks]:

Question 1:
Define the following terms:

a) Newton's second law

b) Newton's third law

(4 marks)

Question 2:
Describe how the angular acceleration (α) can affect the angular velocity (ω) (its magnitude and direction) for the following two situations:

a) When α and ω are in same direction.

b) When α and ω are in opposite direction.

(4 marks)

Question 3:
a) Write an equation for the gravitational potential energy of a satellite mass m at a distance r from the center of the Earth of mass M_E.

b) A book of mass m falling to the ground from a table of height h, its total energy at any point along its path is the sum of its kinetic energy ($0.5mv^2$) and potential energy (mgh), where g is 9.81 m/s^2. How does this equation of total energy need to be modified for the case of an asteroid at some thousands of kilometers falling towards ground (Earth)?

(4 marks)

Question 4:
a) Explain the terms "Stress" and "Strain" of a wire in the Mechanics of matters.

b) Draw free body diagrams for a block of solid wood when it is placed on the ground and when it sinks to the bottom of a container that is filled with water.

(6 marks)

Question 5:
Describe the characteristic of the acceleration (a) for a system that perform simple harmonic motion.

(2 marks)

Continued...

Section B [LO2, 30 marks]:

Question 6:

An object, *A*, of mass 2.0 kg is placed at rest at edge of a smooth table. The edge is 50 cm above the floor as shown in **Figure Q6**. An object, *B*, of mass 1.5 kg moves towards object *A* at constant speed of 2.0 m/s. After colliding with object *A*, object *B* moves in opposite direction with speed of 0.8 m/s. Assuming air resistance is negligible, find the horizontal distance travelled by object *A* when it reaches the floor.

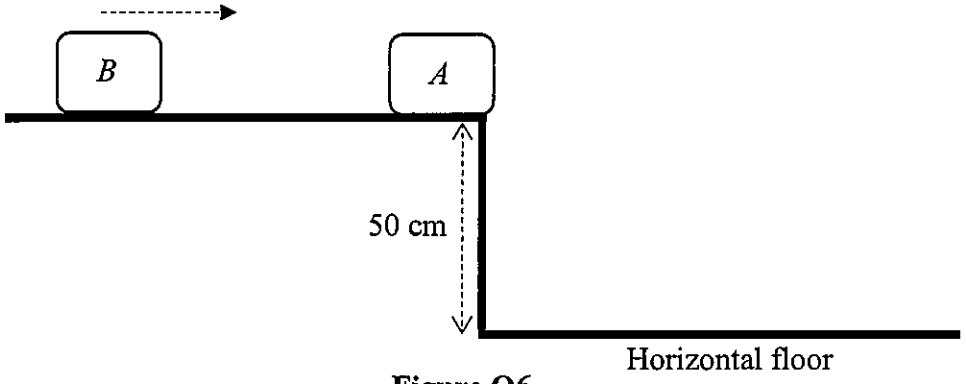

Figure Q6

(6 marks)

Question 7:

An Electric fan, of moment of inertia 2.5 kg.m^2, is turned off and its angular velocity decreases linearly from 650 rpm to 100 rpm in 10.0 s.

a) Find the frictional torque which rendered the drop in its angular speed.

b) How many more seconds are required for the fan to come to rest if the frictional torque remain constant at the value calculated earlier in part a) ?

c) Based on b) above, how many revolution the fan have turned before coming to a stop?

(6 marks)

Question 8:

a) A projectile is fired straight upward from the Earth's surface at the South Pole with an initial speed equal to one third the escape speed. Ignoring air resistance, determine how far the projectile travels before stopping momentarily.

b) Two objects attract each other with a gravitational force of magnitude 1.0×10^{-8} N when separated by 20.0 cm. If the total mass of the objects is 5.00 kg, what is the mass of each?

(6 marks)

Question 9:

a) The gravitational force exerted on a solid object is 5.00 N as measured when the object is suspended from a spring scale as in **Figure Q9a**. When the suspended object is submerged in water, the scale reads 3.50 N as in **Figure Q9b**. Given that the density of water is 1000 kg/m^3, find the density of the object.

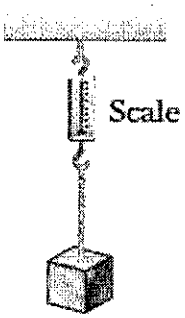

Figure Q9a

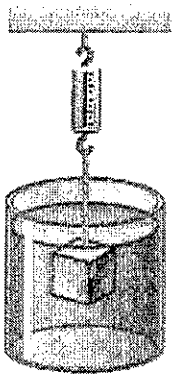

Figure Q9b

b) A 25.0-m long steel cable with a cross-sectional area of 2.03×10^{-3} m^2 is used to suspend a 3.50×10^3-kg container. Given that Young's Modulus of steel is 20×10^{10} Pa, by how much will the cable stretch once bearing the load?

(6 marks)

Question 10:

The equation of motion of a mass-spring undergoing simple harmonic motion is given by $x = (12.0) \cos (4\pi t - \pi/4)$, where x and t are in meter and second respectively. If the mass is 2.0 kg, find

a) its initial position,

b) its initial velocity, and

c) the total energy.

(6 marks)

End of Paper

APPENDIX I

Physical Constants

Quantity	Symbol	Value
Electron mass	m_e	9.11×10^{-31} kg
Proton mass,	m_p	1.67×10^{-27} kg
Elementary charge	e	1.602×10^{-19} C
Gravitational constant	G	6.67×10^{-11} N.m^2 /kg^2
Gas constant	R	8.314 J/K.mol
Hydrogen ground state	E_o	-13.6 eV
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Compton wavelength	λ_c	2.426×10^{-12} m
Planck's constant	h	6.626×10^{-34} J.s
Speed of light in vacuum	c	3.0×10^8 m/s
Rydberg constant	R_H	1.097×10^7 m^{-1}
Acceleration due to gravity,	g	9.81 m /s^2
Atomic mass unit (1u)	u	1.66×10^{-27} kg
Avogadro's number	N_A	6.023×10^{23} mol^{-1}
Threshold of intensity of hearing	I_o	1.0×10^{-12} W /m^2
Coulomb constant	k	8.988×10^9 N m^2 /C^2
Permittivity of free space	ϵ_o/κ_o	8.85×10^{-12} C^2/N.m^2
Permeability of free space	μ_o	$4\pi \times 10^{-7}$ H/m

Energy equivalent of atomic mass unit:

One atomic mass unit (1.0 u) is equivalent to 931.5 MeV

Earth:

Gravity	=	9.81 m s^{-2}
Radius	=	6.38×10^6 m
Mass	=	5.98×10^{24} kg

Moon:

Mass	=	7.35×10^{22} kg
Radius	=	1.74×10^6 m

Sun:

Mass	=	1.99×10^{30} kg
Radius	=	6.96×10^8 m

Mean distance from:

Sun to Earth	=	1.50×10^{11} m
Moon to Earth	=	3.85×10^8 m

APPENDIX II

List of Formulas

$y = kx^n$ $\frac{dy}{dx} = knx^{n-1}$	$sin\,\theta = \frac{\text{opposite}}{\text{hypotenuse}}\ cos\,\theta = \frac{\text{adjacent}}{\text{hypotenuse}}$ $tan\,\theta = \frac{\text{opposite}}{\text{adjacent}}$ $sin\,\alpha + sin\,\beta = 2\,cos\left(\frac{\alpha-\beta}{2}\right) sin\left(\frac{\alpha+\beta}{2}\right)$ $sin(\alpha-\beta) + sin(\alpha+\beta) = 2\,sin\,\alpha\,cos\,\beta$

$v = v_o + gt$ $\quad y - y_o = v_o t + \frac{1}{2}gt^2$ $\quad v^2 = v_o^2 + 2g(y - y_o)$

$y - y_o = \left(\frac{v_o+v}{2}\right)t$ $\quad v = \frac{\Delta x}{\Delta t}$ $\quad a = \frac{\Delta v}{\Delta t}$ $\quad v = \sqrt{\frac{GM}{r}}$ $\quad v = \sqrt{\frac{2GM}{r}}$

$a_c = \frac{v^2}{r}$ $\quad F_g = G\frac{m_1 m_2}{r^2}$ $\quad U_g = -G\frac{m_1 m_2}{r}$ $\quad T^2 = K_s r^3$

$\tau = rxF$ $\quad \sum\tau = \tau_{net} = I\alpha$ $\quad I = \sum mr^2$ $\quad v = r\omega$

$L = rxp = I\omega$ $\quad K = \frac{1}{2}I\omega^2$ $\quad |\tau| = |r||F|\,sin\,\theta$

$T_s = 2\pi\sqrt{\frac{m}{k}}$ $\quad T_p = 2\pi\sqrt{\frac{l}{g}}$ $\quad T = \frac{2\pi}{\omega} = \frac{1}{f}$ $\quad \overline{y} = \frac{\sum_{i=1}^{N} m_i y_i}{\sum_{i=1}^{N} m_i}$

$x = A\,cos\,\omega t$ $\quad v = -\omega A\,sin\,\omega t$ $\quad a = -\omega^2 A\,cos\,\omega t$ $\quad x = A\,sin\,\omega t$

$v = \omega A\,cos\,\omega t$ $\quad a = -\omega^2 A\,sin\,\omega t$ $\quad W_F = |r||F|\,cos\,\theta$

$v = v_o + at$ $\quad x - x_o = v_o t + \frac{1}{2}at^2$ $\quad v^2 = v_o^2 + 2a(x - x_o)$

$x - x_o = \left(\frac{v_o+v}{2}\right)t$ $\quad W = mg$ $\quad \sum F = F_{net} = ma$ $\quad f_s \leq \mu_S F_N$

$f_k = \mu_K F_N$ $\quad p = mv$ $\quad \sum F = \frac{\Delta p}{\Delta t}$

$\Sigma W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$ $\quad m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$m_1u_1 + m_2u_2 = (m_1 + m_2)v$ $\quad P = \frac{W}{t} = \frac{E}{t} = \frac{Fd}{t} = F\overline{v}$

$K = \frac{1}{2}mv^2$ $\quad PE_s = \frac{1}{2}kx^2$ $\quad F_s = -kx$ $\quad PE_G = mgy$

$\overline{x} = \frac{\sum_{i=1}^{N} m_i x_i}{\sum_{i=1}^{N} m_i}$ $\quad W_{Fs} = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$